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The time determining the resolution of such systems is the sum of the time delay in firing, the time required for glow-current development, and the deionization time. The latter determines the maximum rate of voltage recovery in the lamp after extinction, i.e., the charging rate of the capacitors C_2 . The time delay of firing in the proposed circuits is substantially reduced and stabilized by using the previously suggested method (2, 5) which sets up preliminary ionization between the working electrodes through an independent dark discharge maintained between them. In this method the voltage U_p applied to the starting anodes is greater than the firing potential and the current of the discharge developing is limited by a high resistance ($R_1 > 5M\Omega$) to a value less than the value corresponding to the beginning of the falling section of the volt-ampere characteristic. Thus, the maximum possible ionization will prevail in the lamp, and the firing potential will be automatically established on its starting anode. The initial current is made small enough so that it will not cause a glow discharge from the main anode. Only when the next pulse arrives will a flash, caused by this pulse, fire the lamp.

In contrast to the above-mentioned circuit by Manley and Buckley, the counting rate, when the above method is used, is limited only by the deionization time and may exceed 10,000 pulses per second in an individual unit. Measurements of the deionization time have shown that substantial variations occur even in lamps of the same type.

The lamps in the next unit can be fired because of the high voltage rise while the capacitors C_2 are charging, after the lamp from whose anode this voltage was taken is extinguished, as shown in Figure 1, b. However, since the charging rate of capacitors C_2 is low, the lamps in the next unit will fire only after an appreciable delay. This delay will become even greater because the voltage rise is preceded by a drop which effects a decrease in the initial current. These factors limit the counting rate to 500-700 pulses per second.

To increase the counting rate in the first stages, auxiliary MN-5 type lamps were connected in parallel with the cathode resistor of one lamp in the unit, shown in Figure 1, a. The battery voltage selected was such that, when this particular MTKh-90 fires, the voltage drop across its cathode resistor will be slightly less than the firing potential of the MN-5. If now another lamp of the unit fires from the next pulse, the resulting voltage rise taken from its cathode added to the existing voltage at the MN-5 lamp will exceed the firing potential of the MN-5 and it will fire. The sharp positive pulse developed across resistor R_3 will put the next unit in operation. This method permits us to increase the counting rate to 5,000-7,000 pulses per second. Realization of the maximum counting rate in an individual unit is difficult because the capacitor C_2 can be only partially charged at high pulse frequencies.

Our third circuit, shown in Figure 3, is a ring counter, i.e., firing of one of the lamps involves extinction of the preceding lamp and preparing the following lamp for firing by the next pulse. The preceding lamps are extinguished by the capacitors C_2 which connect the cathodes of all lamps. Firing is produced by the positive pulses to be counted, which are fed to the starting anodes of all MTKh-90 lamps. However, in order that the next pulse will fire only the lamp following the one already fired -- and not the other lamps -- small MN-3 neon lamps are connected between the cathode of each preceding lamp and the starting anode of the following lamp.

Since MTKh-90 firing potentials are not identical, an initial independent discharge should exist in only one of these lamps. If the preceding MTKh-90 is not fired, the voltage at the starting anode of the next lamp will be determined by the firing potential of the MN-3, because the latter is considerably less than the firing potential of the MTKh-90. Since there is no initial ionization in the MTKh-90, the incoming pulse cannot cause it to fire. However,

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if the preceding lamp is fired, the voltage at the starting anode of the next MKh-90 will rise because of the voltage drop across the cathode resistance of the preceding lamp; an independent dark discharge will thus be set up in it to prepare the lamp for firing by the next pulse. Another function of the MN-3 is to limit the amplitude of incoming pulses. Only if the preceding MKh-90 has been fired will the dark discharge in the corresponding MN-3 be interrupted. For this reason, its inertia will increase sharply and the pulse will enter the starting anode of the next MKh-90 without a decrease in amplitude.

The output tube operates at each n th pulse, where n is the number of counting units determining the scaling ratio. The row number of the fired lamp indicates the number of pulses which are not multiples of n . The extremely economical operation of the proposed circuit differentiates it from other counting circuits, especially from thyatron circuits. The power drawn by a 100-multiple counting circuit consisting of two cascaded decade rings is less than 0.1 W. Such economy is close to the limit, since practically all the current is used only to fire the two lamps acting as indicators of the number of pulses counted. The economy and simplicity of the circuit make it possible to do without a mechanical counter at the output and to replace it by several additional scale-of-10 rings. According to resolution, which can be reduced to $1-1.5 \cdot 10^{-4}$ sec, the proposed circuits are as efficient as either thyatrons or even certain circuits operating on electronic tubes, e.g., L'yois's circuits (3). The manufacture of tubes with a shorter deionization time would greatly reduce the resolving time.

It has been assumed that the simplest circuit for driving a mechanical pulse counter is one using a thyatron (3). But Figure 4 shows a simpler circuit operating on a MKh-90 neon lamp. Because of the high initial ionization, the sensitivity of the lamp is increased considerably. The circuit can operate not only on positive, but also on negative pulses, if they are not too short and if they are fed from a pulse source with low internal resistance. When a negative pulse is delivered, and dark discharge stops and capacitor C_1 begins to charge quickly. The dark discharge current, capable of limiting the voltage rise at the starting anode, reappears, but not at once because of the inertia of the discharge. For the parameters shown in Figure 4, the voltage at capacitor C_1 will exceed the firing potential while the dark discharge is developing, thereby firing the lamp a moment later. Unless the voltage supplied to the starting anode is substantially higher than the firing potential, the circuit will operate only on positive pulses (Figure 1, c).

Because of the inductance in the winding of the counter coil or relay, a strong positive pulse, the induced emf, appears when the plate circuit is opened, building up a capacitive charge across the open contacts. As the emf decreases, the plate voltage drops. If the emf is high, the plate potential becomes negative to such an extent that firing occurs with reversed polarity of the tube electrodes. The motion of the descending armature of the counter maintains the emf, and the tube fires till the contacts reclose. Since the tube does not have time to deionize, it immediately fires again, causing humming in the counter. Connecting in tripping contacts, as shown in Figure 4, and grounding the counter core help to decrease the voltage drop because it is divided between the capacitance of the contacts and that of the winding. Connecting in resistance $R_3 > 5M\Omega$ facilitates smooth voltage recovery at the tube plate and eliminates the other type of humming produced by the inductive kick at the instant the contacts close.

When neon lamps are used, a capacitor connected in parallel with the open contacts (3) only makes the situation worse. Besides, its use causes burning of the contacts, making operation less reliable. Connecting a high capacitance (1 μ fd) in parallel with the counter coil for spark quenching (3) decreases the maximum counting rate and damages the lamp. Use of a resistance R_2 having three to ten times the resistance of the counter winding (Figure 4) reduces the pulse

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emf to a permissible value $U = IR_2$, where I is the current flowing across the winding before the contacts open. In high-speed counting, the increase in current consumption produced by this resistor is practicably negligible when compared with the current required to charge a 1 μ fd condenser.

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3. V. L'yuis [possibly W. B. Lewis], Methods of Counting Alpha and Beta Particles, Moscow, Leningrad, 1949.
4. L. Korablev, Certificate of Authorship No 87398, 10 July 1948.
5. L. Korablev, Certificate of Authorship No 87417, 10 July 1948.

[In the figures on the next page, the following key, taken from Radio, No 2, 1950, probably applies. C 65 = 65 μ fd; C 3T = 3,000 μ fd; C 5.5T = 5,500 μ fd; C 0.3 = 0.3 μ fd; C 4.0 = 4.0 μ fd; R 800 = 800 Ω ; R 40T = 40,000 Ω ; R 0.2 = 0.2 M Ω ; R 2.0 = 2.0 M Ω . Thus, in Fig 1, 3 and 4 R₁ 5.0-10.0 = 5.0-10.0 M Ω , R₂ 0.1-0.2 = 0.1-0.2 M Ω , C₁ 30-50 = 30-50 μ fd, and C₂ 1-5T = 1,000-5,000 μ fd.]

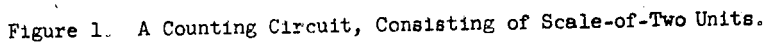
[Figures follow.]

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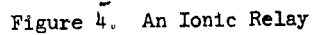
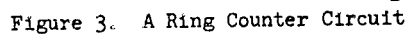
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